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**EFFECTS OF STRESS ON JUDGEMENT AND DECISION MAKING IN DYNAMIC TASKS**

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for

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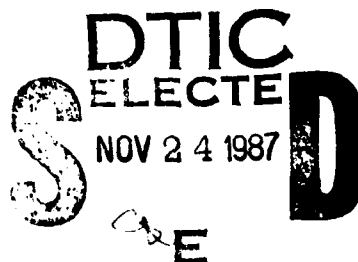
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EFFECTS OF STRESS ON JUDGMENT AND DECISION MAKING IN DYNAMIC TASKS  
1 September 1986 - 31 August 1987)

Kenneth R. Hammond (University of Colorado, Boulder), Principal Investigator

EXECUTIVE SUMMARY

Goals

The principal goals of this research project are to: (a) discover the nature of judgment and decision making in dynamic tasks; (b) study the effects of stress on judgment and decision making in such tasks. Neither project has been undertaken previously by researchers in this field.

Initial Plan of Work

We had intended to (a) study college sophomores and others in laboratory situations (Year I), (b) move to the study of professional experts in dynamic tasks (Year II) and (c) study experts under stress in dynamic tasks (Year III). This plan was changed midway in the first year when it became apparent that we would have an excellent--and rare--opportunity to move directly to the situation planned for Year II; that is, to the study of weather forecasters coping with dynamic tasks (forecasting microbursts, hail, and severe weather) with a clear possibility of working with these same experts (and same tasks) under stressful conditions, thus providing continuity in moving us directly toward our principal goals. Because of the recognition of the importance of research of this sort, the Center for Atmospheric Research (NCAR) and the National Oceanic and Atmospheric Administration (NOAA) not only offered us the cooperation of their expert forecasters, but offered supplemental funding for the ARI project. As a result we were able to employ additional staff members (an expert Ph.D. level judgment researcher and a research assistant). As our Quarterly Reports have indicated, we moved quickly to take advantage of these unusual circumstances and midway in the first year began work planned to begin in Year II, that is, direct study of experts coping with dynamic tasks.

Current Efforts

We have undertaken three projects (the study of meteorologists' efforts to forecast microbursts, hail, and severe weather). Each is described in turn.

### Microburst Forecasting

The invitation to participate in this project (sponsored by the Federal Aviation Administration) offers the unusual opportunity to study experts who are attempting to (a) understand a type of dynamic environmental activity (weather phenomena of critical importance to air travel) and (b) forecast its occurrence. Moreover, the meteorologists who are undertaking this work are provided with the most sophisticated state-of-the-art information gathering and display devices available (e.g., Doppler radar), thus providing us with laboratory conditions ordinarily unimaginable. And because of the full cooperation of the project manager and staff meteorologists, we have been able to make field observations as well as laboratory-type studies of these experts' efforts to understand and predict the behavior of complex dynamic systems. Each effort is described in turn.

Field observations. During these observations we acquainted ourselves with the complicated computer hardware and software available to the meteorologists, and observed the meteorologists' activities under real time conditions. These observations led us to the conclusion that several sources of information and several display modes are available to the meteorologists. In these conditions, the meteorologists (a) are active seekers of information that changes over time, (b) are active hypothesis generators about what has happened, is happening, and will happen, (c) employ both deductive and inductive inferences, (d) rely partially on scientific principles and partially on empirical regularities and thus employ both functional analyses and pattern matching strategies, and (e) make judgments and decisions about dynamic environmental events under considerable uncertainty that is created by incomplete and imprecise data, and incomplete physical, chemical, and climatological principles. In our view, this situation is far from those ordinarily studied in laboratory situations by psychologists, but highly representative of the vast majority of conditions under which judgments and decisions, military and otherwise, are made. This situation, therefore, is ideal for the present research project. We also concluded that our studies must follow from a new and much more complex psychological theory of judgment and decision making than has thus far been advanced by anyone.

Laboratory-type studies. Our first steps were to discover to what extent the experts would exhibit inter- and intra-observer agreement with regard to the forecasting of microbursts when given (a) perfectly reliable measurements of weather data (assumption that observers of the radar screen and other instruments should show perfect inter- and intra-observer agreement) and (b) perfectly reliable (as observed) interpretations of those data, as for example, interpreting the wind velocities to signify such microburst precursors as "descending core, collapsing storm, etc. Only modest agreement among the experts was found. This result (including the finding that one meteorologist's judgments were far different from the others) was new information to the forecasters. We then investigated the question of whether

the forecasters could translate profile information about storms (as described above) into mental images of the storms, and to what extent the storm images would be similar across forecasters. Although it was found that the forecasters could easily draw schematic diagrams of storms depicted in the profiles, only modest agreement among the forecasters was found with regard to the similarity of storm images. And when asked to transform their storm images back into profiles only a rough translation appeared possible (though analysis is continuing on this question). A Technical Report on the above project is in preparation.

### Hail

This project differs from the microburst project in that actual data including a criterion for evaluating the accuracy of forecasters were available. Cue data (from Doppler radar scans of thunderstorms) and criterion data (observation of hail by chase teams on the ground) were provided by NOAA for 453 cases. Since an expert system for hail prediction has been developed by NOAA, it was possible to set up a competition among forecasters' forecasts, the AI expert system's forecasts, and forecasts based on judgment models of the forecasters. It was found that the three methods of forecasting produced roughly the same accuracy (rather low, because of the inherent uncertainty in predicting hail from the available data). The judgment model, however, is by far the least costly and simplest to employ, and thus the most efficient. We know of only one previous study that made such comparisons; similar results were found. Work on this project continues. The analysis of the data are nearly complete and a Technical Report on this project is in preparation.

### Severe Weather

This study examines weather forecasters' judgments in a dynamic task of critical importance. NOAA provided access to an advanced interactive computer graphics weather forecasting workstation for this experiment, thus providing us with a laboratory of great complexity and representations. Real weather data were replayed in simulated forecasting sessions. Three forecasters, working individually, were asked to think aloud as they decided when and where to issue warnings and alerts for thunderstorms. Their deliberations were tape recorded and a record was kept of their concurrent actions. Comparison of severe weather warnings and alerts issued by different forecasters for the same day indicate that forecasters generally focus on the same storms (of the several apparent), but the actions taken with regard to those storms vary substantially among forecasters. Transcripts of the forecasters' verbal descriptions of their forecasting strategies are being analyzed. They suggest that differences among forecasters are due to differences in (a) selection of information, (b) strategies for integrating information, (c) implicit criteria or thresholds for issuing warnings or alerts. A Technical Report on this project is in preparation.

J/DM in Dynamic Tasks  
Hammond

Theoretical and Conceptual Work

Our study of weather forecasters making judgments in dynamic tasks under actual conditions where instrumentation of considerable complexity is used has led to a definite conclusion about present theory in judgment and decision research, namely, it is far too simple to be of use in dynamic tasks of any reasonable complexity. Therefore we are developing a general theory to account for the cognitive activity of these experts under these complex conditions. A Technical Report is in preparation.